8. Metals[1]

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Winning metals from mineral ore has supported the development of human economy and society since the Stone Age. Today, metals play a vital part in the leading-edge technologies of information and communication. They are crucial in most sectors of the economy. in particular construction, engineering, household goods and appliances. transport and communication systems, and equipment and packaging. Possession of, and access to, minerals and metals gain strategic importance for countries and regions in times of trade disputes and of political uncertainty.

The focus of this chapter is basic metal processing (sector 27 of Eurostat's revised standard industrial classification). It covers the manufacture and processing of both ferrous and non-ferrous base metals.[2] Steel is the principal ferrous metal. Among the non-ferrous metals, copper, aluminium. zinc, nickel and lead are the most important. The significance of tin has diminished over the past quarter-century. Statistical analysis at both EU and national levels now treats the production of the two types of metal as a single sector. The reasons for this include: the decline in metals' share of industrial output and of total economic output (gross domestic product) as electrical and electronic products have grown in importance and as the services sector has increased; increased end-use substitutability among the various types of metal, and between them and other materials, plastic and glass in particular; some common processes; and a recent trend among the major metal producing companies towards the integration of the manufacture and supply of both ferrous and non-ferrous metals.

The basic process of production is common to all metals. Mineral ore is mined and the metal extracted by heating the ore, together with fluxes, in a furnace (smelting). Impurities are removed from the metal by further intense heating (refining). Recycled metal (scrap) may also be used at this stage. The liquid metal is then cast into one of a variety of forms before being shaped into the required profile by rolling or forging. Further rolling, heating and surface treatments may then be applied to give the metal particular physical use characteristics - for example, flexibility or tensile strength.

In 1997 (the most recent date for which comprehensive data are avail-

able), basic metal processing accounted for 4.8 per cent of output and for 4 per cent of employment in the EU manufacturing sector. The sector comprised 16700 enterprises, or less than 1 per cent of the total for manufacturing. Taken together, these data suggest that, in comparison with other sectors, the metals industry may be described as large-scale (Eurostat 2001).

Typically, metals demand and output grow strongly in the early stages of industrialisation, when construction and the manufacture of heavy goods are important. Worldwide, metals output grew at an annual rate of around 4 per cent between 1990 and 2000, with production in China increasing at the fastest pace. Considering the major economies of the EU, the US and Japan, and measuring output in constant Euro prices,[3] the EU is the largest metals producer, accounting for 40.2 per cent of the total in 1996. This compares with 30.2 per cent for the US[4] and 29.6 per cent for Japan. The general economic expansion of the second half of the 1990s drove increases in output, more than offsetting the fall-back in activity during the recession at the start of the decade. In the ten years from 1987, output grew fastest in the US, followed by the EU. The rate of production was almost stationary during the period in Japan, reflecting that country's prolonged recession.

In both the EU and Japan, metals production has declined as a share of total manufacturing since 1980. In all three regions employment fell sharply from the mid 1980s onwards, as slow output growth and strong international competition forced productivity improvements. There were 917000 people employed in the EU metals industry in 1996, compared with 1.43 million ten years before, a fall of more than a third. The sector's international competitiveness has declined since the start of the 1990s. The EU has a persistent trade deficit in metals and exports have declined as a share of all manufactured exports. Imports from central and eastern Europe and from the Russian Federation have increased. The chief export destinations for EU metals are the US and Norway. The major metals producing countries within the EU are Germany (28.9 per cent in 1996); Italy (16.6 per cent); France (14.5 per cent); and the UK (12.0 per cent). Basic production statistics for the industry in the individual Member States are given in Table 8.1.

DEMAND

The demand for basic metals is derived from the rate of production of the goods of which they form part. Table 8.2 shows the main end-uses for the principal metals. The transport and communications sector is significant for almost all metals. Construction is an important outlet for steel and for copper. Steel, aluminium and, to a lesser extent, tin are used for packaging.

Table 8.1 EU metals output by country, 1998

Member state	Crude Steel		Aluminium		Copper		Lead		Zinc		Nickel		Tin	
	kt	%EU	kt	%EU	kt	%EU	kt	%EU	kt	%EU	kt	%EU	kt	%EU
Austria	5298	3.3	126.4	3.5	72.0	4.6	23.1	1.9	.	.	.	.	.	.
Belgium	11423	7.2	.	.	368.0	23.6	120.0	10.1	250.0	12.1	.	.	8000.0	65.8
Denmark	792	0.5	35.0	1.0	.	.	0.5	0.0	.	.	.	.	100.0	0.8
Finland	3928	2.5	.	.	157.7	10.1	.	.	199.0	9.7	46018.0	41.1	.	.
France	20153	12.6	668.8	18.4	22.4	1.4	290.2	24.4	321.0	15.6	11777.0	10.5	.	.
Germany	44046	27.6	374.7	10.3	547.9	35.2	217.8	18.3	357.3	17.3	15005.0	13.4	.	.
Greece	1108	0.7	146.4	4.0	.	.	6.0	0.5	.	.	.	.	150.0	1.2
Ireland	359	0.2	.	.	.	.	.	.	.	.	.	.	.	.
Italy	25677	16.1	689.6	18.9	29.1	1.9	199.3	16.8	231.6	11.2	.	.	.	.
Luxembourg	2477	1.6	.	.	.	.	.	.	.	.	.	.	.	.
Netherlands	6377	4.0	365.7	10.0	.	.	17.2	1.4	217.1	10.5	.	.	.	.
Portugal	936	0.6	3.2	0.1	.	.	6.5	0.5	.	.	.	.	100.0	0.8
Spain	14827	9.3	570.4	15.7	152.4	9.8	.	.	385.0	18.7	.	.	200.0	1.6
Sweden	5122	3.2	122.7	3.4	125.4	8.1	64.5	5.4	.	.	.	.	216.0	1.8
UK	17031	10.7	533.2	14.6	53.8	3.5	243.1	20.5	99.6	4.8	39100.0	34.9	100.0	0.8
EU total	159554	100.0	3641.0	100.0	1557.0	100.0	1188.0	100.0	2061.0	100.0	111900.0	100.0	12155.0	100.0
% World		29.9		12.6		11.5		21.6		25.2		12.1		5.0

Notes:
. Zero or negligible
.. Data not available

Sources: United Nations (2000).

Table 8.2 Main end-uses of the principal base metals

End-use / Metal	Construction	Automotive	Aerospace	Electrical Engineering/ Electronics	Mechanical Engineering and Fabrication	Packaging
Ferrous:						
Steel	X	X			X[a]	X
Non-ferrous:						
Aluminium		X	X			X
Copper	X			X[b]		
Nickel						
Zinc		X			X	

Notes:
[a] Including household appliances.
[b] Including cables and wire.

Source: Industry information.

Metals demand overall is driven by an economy's size, growth rate and stage of development. For a mature economy, consumption typically will increase at a slower pace than GDP as the shift towards the supply of technology goods and of services causes the metal intensity of total output to decline, and as imports of metal-using finished goods increase. By contrast, in the early stages of industrialisation, demand for metal tends to be high as expenditure is directed towards construction, infrastructure, transport equipment and capital goods. Price is secondary to real income (GDP) as an influence on demand - income elasticity of demand is high, while the sector's price elasticity is low. Suppliers generally are price takers rather than price makers, as they provide largely standardised commodity products to knowledgeable buyers. Prices tend to rise and fall with the economic cycle. There is little incentive for individual suppliers to make unilateral price adjustments. A price cut by one supplier will be matched rapidly by competitors, whereas a price increase will not: the price elasticity of demand for *individual* suppliers for a unilateral upward shift in price is therefore high.

The demand for some metals complements that of others. Nickel is used mainly as an alloy in the manufacture of stainless steel; zinc is used predominantly for galvanising steel sheet to make it rust-resistant; and tin is used chiefly to coat steel in the production of tin-plate. In other cases, metals can be substitutes; for example, steel and aluminium compete strongly with each other and with other materials in the packaging and the transport markets. The degree of substitution is affected by price differences, by changes in consumer preferences (for example in the case of packaging for beverages), and by technological improvements such as the development of thin gauge steel.

Across the EU Member States, metal consumption rates vary broadly in line with real GDP. The main producer countries (Germany, Italy, France and the UK) meet about half of their direct demand from home production. The other countries rely mainly on imports, both from within the EU and from outside. Import penetration and cross-trading have generally become more important in recent years as barriers to trade have come down; as imports from eastern and central Europe and the Russian Federation in particular have increased; and as the production of some grades of metal (for automotive use, for example) has become more specialist. Increased imports of metal-using finished goods (for example, motor vehicles, home appliances, electronic goods) have been an important factor in weakening the link between the rate of economic growth and the direct demand for metals.

SUPPLY

Annual production of metals in the EU, as measured by the gross value of output at constant prices, fell after the boom of the late 1980s until 1993 and then began a hesitant recovery. The rate of output has been generally flat over the period as a whole. Production has lagged behind the growth of both metals consumption and GDP. The sector performed better than in recession-bound Japan but was outpaced by vigorous growth in the US.

Eurostat data split the industry into the five sub-sectors shown in Table 8.3. Basic iron and steel production represents two-fifths of total value added while output of non-ferrous metals accounts for one-fifth of the total. Casting (16 per cent of total value added) is principally of ferrous metals – hence iron and steel manufacture is typically more integrated vertically than is production of non-ferrous metals.

Table 8.3 Sub-sectors of the EU basic metals sector (NACE Rev. 1.27)

27:	Manufacture of basic metals
27.1:	Manufacture of basic iron and steel and of ferro-alloys[a]
27.2:	Manufacture of tubes
27.3:	Other first processing of iron and steel and production of ferro-alloys[b]
27.4:	Manufacture of basic precious and non-ferrous metals
27.5:	Casting of metals

Notes:
[a] Ferro-alloys as classified within the terms of the European Coal and Steel Community (ECSC).
[b] Non-ECSC ferro-alloys.

Source: Eurostat (2001).

The nature and degree of vertical integration differ between the ferrous and non-ferrous metals sub-sectors, generally according to the distribution of value-added throughout the chain of production as suppliers focus on those parts in which they have greatest competitive advantage. The larger steel producers typically link together smelting, refining, casting and rolling and finishing, whereas non-ferrous metals producers are more heavily involved upstream, in mining of minerals. For the latter, the greater part of value added is realised at the mining and refining stages – for example, about four-fifths of the final cost of a copper tube is made up of mining and primary processing costs whereas the equivalent figure for steel tubes is only about a third. Metals producers generally avoid fabrication of non-ferrous metals because it is a fragmented, low value-added, low margin,

highly competitive business. In contrast, the value-added contribution for steelmakers is mainly at the downstream processing stage. Aluminium is the exception to this general pattern; the leading producers integrate all stages of the process from mining to delivery of final consumer products – for example, baking foil and beverage cans. Their capacity, however, is not evenly balanced at each stage. Integrated producers may need to buy-in primary metal to feed refining furnaces and rolling mills. So far in the sector's development, suppliers tend to specialise in the production of a given type of metal – steel, aluminium, copper, zinc, and so on. The cross-elasticity of supply within individual firms is therefore low.

Production is concentrated in four countries – Germany, Italy, France and the UK – which together account for over 70 per cent of total annual output. Together with Spain, Belgium–Luxembourg and Sweden, their combined output represents 90 per cent of the total. Germany is the leading producer in each sub-sector by a substantial margin. Italy is strong in tubes, casting and processing of ferrous metals. France is a leading producer of iron and steel, while the UK has relative strength in non-ferrous metals production. Among the smaller producing countries, Sweden is a leading supplier of high-quality special steels while the steel industry in Spain has grown rapidly recently as inward investment has added capacity to take advantage of low labour costs.

Output has been supported increasingly by export sales. For iron and steel production, export sales were 11.2 per cent of total production in 1989 but their share had risen to 15.8 per cent by 1996; the comparative proportions for non-ferrous metals were 15.9 and 21 per cent respectively (Eurostat 2001, Tables 8.9, 8.10, 8.24, 8.25). The main export destinations are the US and East Asia.

MARKET STRUCTURE

The metals sector is characterised on the sellers' side by a high degree of concentration. On the buyers' side, purchasers are typically commercially and technically knowledgeable and, in some segments, have power themselves through concentration. More than 70 per cent of both turnover and employment in the sector is contained in large enterprises – those employing 250 or more workers. In terms of employment, concentration is highest in Belgium (84.1 per cent), followed by Germany (81.3 per cent). It is lowest in Italy (52.1 per cent), reflecting the more fragmented pattern of organisation of production in that country (Eurostat 2001, Table 8.1).

Minerals and Mining

Mineral mining and initial processing to supply metals producers with ore and concentrate are organised on a global basis. The major companies are both London-registered: BHP Billiton, formed by the merger of an Australian enterprise with a South African firm, and Rio Tinto, which has consolidated its European and Australian subsidiaries. Each owns and works mines yielding both ferrous and non-ferrous minerals. Until recently, mining companies recognised implicitly each other's principal geographical domain but, as demand has become increasingly global and secure access to mineral deposits has increased in importance, worldwide corporate expansion has taken place through mergers and through joint ventures to develop new supplies.

Steel

The EU is home to five of the world's ten largest steel companies (Table 8.4). Arcelor, formed in 2002 by the merger of Usinor of France with Arbed of Luxembourg and its Spanish subsidiary, Aceralia, is the world's largest steel producer. Each EU steelmaker has gained scale recently by means of mergers and acquisitions. For Arcelor and Corus, these have involved for the first time significant cross-border alliances. This process is changing the industry's hitherto national structure in which, for the leading steel producing and consuming countries, most of supply came from assets owned and

Table 8.4 The world's ten largest steel companies, 2000

Company	Country of registration	Crude steel production (million tonnes)
Arcelor[a]	France	54.6
Nippon Steel	Japan	28.4
Posco	S Korea	27.7
Ispat International	Netherlands	22.4
Corus	Netherlands	20.0
Thysssen Krupp	Germany	17.7
Shanghai Baosteel	China	17.7
NKK	Japan	16.0
Riva	Italy	15.6
Kawasaki	Japan	13.0

Notes: [a] Usinor, Arbed and Aceralia merged.

Source: Financial Times 20 March 2002.

operated domestically. This pattern arose from the interplay of several factors: steel has been an important strategic material for both industrial and military purposes; before free trade within the EU, countries used tariffs and quotas to protect their domestic markets; subsequently, subsidies (both explicit and tacit) were used as protective devices; and, in some cases, government support for, and involvement with, steel producers led to public ownership.

A number of the forces that are now moving the steel industry towards an integrated European pattern gained strength during the last quarter of the twentieth century. First, governments became unwilling to bear the burden of financial support for their steel producers, as pressures to curb public spending increased. They retreated from involvement by cutting subsidies and by offering for sale the assets they owned – privatisation. Next, the end of the Cold War and developments in military technology reduced steel's strategic significance. Third, globalisation encouraged freer international movement of commodities, goods and financial capital, reducing the threat of difficulties in procuring supplies and investment. It also intensified competition.

The industry is reorganising to remove surplus capacity, to reduce costs and improve productivity, and to concentrate on supplying the internal market, where its competitiveness is stronger on account of its substantial market share, and prices can be better sustained. Three companies now supply 60 per cent of total production. EU steelmakers typically integrate iron and steelmaking with rolling and finishing, the stages at which most of the value-added is achieved. The principal companies are developing distinctive strategies in their approach to the market. Arcelor, the Franco-Luxembourg group formed in 2001 and including Arbed's Spanish subsidiary, is planning to trade throughout the EU and beyond, offering a range of steel products. Corus, formed by the merger of British Steel with Hoogovens of the Netherlands has a wider product range and also has had interests in aluminium production. Thyssenstahl of Germany, the third-largest, plans to offset its scale disadvantage relative to the others by focusing closely on the core and periphery of the German market, and by emphasising high-quality flat product production.

Ispat, now the world's eighth-largest steelmaker and with a significant presence in the EU market, is the main exception to the pattern of vertical integration and focus on the internal market. Originally a steel-trading firm based in India, with the entrepreneurial drive of Lakshmi Mittal, its founder, it has progressively acquired assets in Germany, Ireland, the UK, Mexico and the United States where, in 1998, it acquired Inland Steel, then the country's fourth-largest steel producer. Until this point, Ispat had concentrated on small-scale steelmaking technology, using powdered ore and

recycled metal (scrap) as feedstock. Small-scale technology (mini-mills) now accounts for almost 50 per cent of US steel output and it is striking that, so far, this pattern has not developed in the EU.

Finished steel is distributed either directly to the end-user, as in the case of sheet and strip steel to the automotive industry, or is sold to stockholders or, increasingly, to steel service centres. Direct sales are typically made under annual fixed-price contracts, whereas other shipments are generally at spot prices. Contract sales, typically of flat-rolled products, can represent as much as a third of the value of sales to the internal market by EU producers. Buyers are typically large, well-informed, and may engage closely with their suppliers in specifying quality standards. Stockholders offer to their customers storage and breaking of bulk, chiefly of undifferentiated long products, such as bars, rods, beams and sections. Steel service centres, in contrast, further process steel to tailor the product more closely to customer needs and so to add value. As imports from outside the EU take an increasing share of the market, making competition more intense, steelmakers have begun to purchase distributors in order to maintain and increase their market shares, to achieve firmer prices and to capture more of the value added.

Non-ferrous Metals

The extent of vertical integration in the non-ferrous metals sector varies mainly by type of metal. Aluminium and nickel production show the highest degree of integration, and copper manufacture the lowest. In each case, as noted above, and in contrast to steel, the forces driving verticalisation lead producers to integrate upstream, towards the primary inputs of minerals and energy. This is because the greater part of added value is achieved at the smelting and refining stage; shaping and profiling, fabrication, and the manufacture of metal goods are typically low margin activities.

Copper and aluminium are this industry's principal products. The world's leading producers of refined copper are Grupo Mexico, and Phelps Dodge of the US. These are vertically integrated international businesses, linking mining with finished product output. In the EU, by contrast, copper production has focused on the refining stage and has until recently been organised on a relatively small-scale, mainly national, basis. Germany and the UK are the leading producers. Firms are typically custom-smelters, often owned by metals traders. Producers buy-in copper concentrate on the world market and process it into cathode – flat plate weighing about 100 kilos. This is then sold for further processing as wire rod, or as brass mill products. Wire rod is used by the wire and cable industry. Brass mill

products are diverse items including plumbing goods, roofing materials, and high-quality leaf frames for components for computers and other information technology products. Copper producers have not moved forward into wire and cable manufacture, or into electronic component production, because both of these require specific high-technology knowledge and experience; moreover, in the case of wire and cable, there are already large-scale suppliers in the market, for example BICC.

Copper producers sell a standardised product (copper cathode) of specified quality into a highly-competitive, price-driven market. So far, the industry in the EU has sustained competitiveness by investing in leading-edge technology and by achieving high levels of productivity and efficiency. But it now faces a difficult situation. It has high labour costs relative to producers located in Eastern Europe, in Asia or close to mineral deposits, and it carries an increasing burden of environmental regulation, intended to curb sulphur emissions and effluent. Consolidation among producers is beginning to occur. This is helping to remove surplus refining capacity and is leading progressively towards cross-border linkages and European integration.

Aluminium production is a globally-organised, vertically-integrated industry. The leading producers, accounting for around two-thirds of world output, are Alcoa of the US, Alcan of Canada, and Pechiney of France. Surplus capacity has been a feature of the industry for many years; in the 1980s the leading companies signed a Memorandum of Understanding, which is still in operation, agreeing to keep specified amounts of capacity out of operation in order to support prices and sustain 'orderly marketing'. Remarkably, the agreement was given exemption under US anti-trust (competition) law. Recently, mergers and acquisitions have begun to reshape the global industry. Alcoa and Reynolds, the second-largest US aluminium producer, merged in 1999; in turn, this prompted a proposal for a three-way merger between Alcan, Alusuisse of Switzerland, and Pechiney of France. This, however, was proscribed by the EU competition authorities on account of the anticipated detriment that consumers would suffer as a result of concentrating a high degree of European flat-rolled aluminium manufacturing capacity in the hands of one supplier. But an attenuated merger between Alcan and Alusuisse went ahead, leaving Pechiney for the time being as an independent force.

The EU accounts for about one-eighth of the world's aluminium refining capacity. Refining is a capital-intensive, large-scale, energy-intensive process. The competitiveness of the industry in the EU is being sustained by tariffs on imports and has been assisted by subsidies for electricity and water provision.

Among the other metals, zinc production in the EU, like copper, is in the

hands of custom-smelters; their principal customers are steel mills making galvanised metal for use in the automotive industry. Competition is strong and consolidation is taking place in the industry. Nickel is used mainly as an alloy in the manufacture of stainless steel. Its smelting and refining are carried out chiefly by the specialist stainless steel producers, in particular those in Scandinavia. Tinplate manufacture is usually an adjunct of steel production.

COSTS AND TECHNOLOGY

Costs and Capacity

Metal refining and manufacture is a capital-intensive, high fixed cost operation. Table 8.5 shows representative proportionate cost distributions for steel, aluminium and copper production. Fixed costs – capital and other overhead charges, together with a significant part of labour costs – form between one-third and two-fifths of total costs. Fixed charges are particularly important in the first stages of aluminium production. Because steel mills and other metal refining and manufacturing facilities are highly specific for their purpose, the cost of capital is also a sunk cost: the assets cannot be used for purposes other than that for which they were designed and, in a weak market, the scope for recouping all or some of the investment is only through producing and selling output.

These features have important consequences for the structure of the sector and for the behaviour of its firms. As prices fall below full costs in

Table 8.5 Representative production cost distributions, by type of metal (percentages)

Stage of production	Production Cost Distribution		
	Aluminium	Copper	Steel
Mining and primary processing	30	50	5
Smelting	60	10	10
Refining	5	5	40
Rolling and fabricating			30
Overheads	5	35	15

Sources: Graham (1982); Brown and McKern (1987); industry information.

the downswing of the cycle of activity, or as competition intensifies, producers will continue to supply so long as price is greater than average variable cost. This enables at least some contribution to be made to the fixed costs, which are unavoidable, thereby reducing accounting losses. If, as is often the case, some part of capital charges represent depreciation (an accounting convention to allow for the use of assets but which does not involve the movement of funds), firms may record accounting losses but still remain cash-positive – that is, generate more cash than they spend. In these circumstances they can remain in business until the time comes for them to replace their capital assets. Metal manufacturing plant and equipment tend to be long-lived. As a result, capacity remains in operation for a long time, even though demand may be weak and losses are being incurred.

This is an example of a barrier to exit. There is no advantage to a firm in being the first to halt production or leave the sector because that will merely pass market share and revenue to competitors and will involve redundancy and closure costs – better to continue until the expected upturn in the market occurs. The problems with this are obvious: continued over-production harms all producers by depressing prices, increasing losses, and discouraging investment in new technology; and the improvement in the market may not take place because the fall in demand is permanent rather than cyclical. The market mechanism's failure to bring supply into balance with demand in these circumstances may encourage producers to agree to limit output and remove capacity in order to maintain prices. This has happened, exceptionally, in aluminium but is generally illegal under competition law. An alternative in the past in the steel industry, where the survival of 'national champions' and the preservation of jobs have been important, has been for governments to subsidise producers until they have been able to make the necessary adjustments. The flaw in this has been that subsidies have generally prolonged the problem they were intended to solve.

Economies of Scale and Scope

Metals production is generally organised on a large scale: the leading producers together account for the greater part of output in the EU. Large seller concentration is particularly high in the steel and aluminium industries. Metal mills typically integrate smelting, refining and casting, while the biggest enterprises extend from mining to the delivery of finished product to the end-consumer. Mill-level integration is explained by the technical and cost advantages that come from linking together sequential processes that require heat and for which stringent quality control is necessary. Enterprise integration brings benefits from balancing together processes that have different critical minimum scales (mining, refining, processing,

distribution): from multiple plant operation in order to produce a range of products and supply several geographical markets; from increased market power in relation to suppliers and customers; from greater ease and lower cost of raising capital; and from the ability to spread technical, commercial and financial risks. The benefits to the large enterprise from supplying a range of products (economies of scope) come mainly from advantages in marketing.

At mill level, the sources of economies of scale are mainly technical. Manufacturing consists of processing hot liquid metal continuously or in batches in a series of tanks and vessels. The standing capacity of these can be varied over a wide range. In line with general engineering experience, the capital cost of mills does not increase in direct proportion with the expansion of designed annual production capacity, but by rather less, so that capital costs per unit of capacity fall as scale is increased. A rule-of-thumb is that total capital costs increase with capacity to the power 0.6.[5] Moreover, scaling-up does not increase proportionally the number of workers required: here the power factor is around 0.2.[6] Increased scale may also improve the efficiency of use of energy and other utilities.

The most scale-sensitive stages of metal production are smelting, refining and primary rolling. Integrated mills, as well as avoiding the costs of reheating between stages, can combine – on the principle of the least common multiple - different numbers of plant units at each stage to achieve balanced and efficient capacity throughout the mill. The logic of this, in steel and aluminium production in particular, is that the most efficient scale of plant may be very large indeed. In the 1960s and 1970s steel mills were built in Japan with annual capacities of up to 12 million tonnes, while in the EU several large plants were developed with annual capacities up to 5 million tonnes (Dunkerque and Fos-sur-mer in France, Taranto in Italy, IJmuiden in the Netherlands). In the case of aluminium, a much lighter metal than steel, economies of scale extend up to an annual capacity of 350 thousand tonnes.

Table 8.6 gives estimates of the minimum technical efficient scale of plant for the main types of metal, and relates them to the sizes of the whole EU market and the largest national market within it. Enterprises that choose to supply a full range of product to the market will need typically to operate several plants since, for technical reasons, individual mills tend to be dedicated to a limited product range. This means that the minimum scale of firm will be a multiple of the minimum technical efficient scale of plant.

The notion of economies of scale has been a powerful factor in shaping the global metals industry. But caution is required. Increasingly, end-users demand flexibility of production and supply, to which large-scale units are not well-suited. Some sacrifice of size may be worthwhile if agility of

Table 8.6 Minimum technical efficient scale of plant for basic metal manufacture, by type of metal

Type of metal	Minimum technical efficient scale (thousand annual tonnes)	Share of EU annual output 1998 (%)	Share of output of largest market 1998 (%)
Aluminium	350	9.6	50.8
Copper	100	6.4	18.3
Steel:			
• integrated	5000	3.1	11.4
• mini-mill	2000	1.3	4.5

Sources: Aluminium and copper: Brown and McKern (1987) and industry information; steel: Cockerill (1973), Barnett and Crandall (1986); output data: United Nations (2000).

supply is improved. Moreover, technical change may undermine economies of scale.

New Technology

The most remarkable feature of the steel industry in the US over the past quarter of a century has been the rise in importance of mini-mills (Barnett and Crandall 1986). These use electric furnaces to melt scrap steel which is then continuously cast into either long lengths of rectangular cross-section (billets) or into thin slabs, for further processing. At first, most of their output was sold into the construction industry as reinforcing bars. Their advantages are that they: avoid the heavy overhead and operating expenses of primary iron and steel smelting and refining; make use of energy-intensive recycled steel scrap; are flexible in the quality of steel production; and can be located close to their final markets (which also generate most of their scrap). Mini-mills' development in the US has been aided by falling real electricity costs as deregulation has taken place; by ample supplies of scrap as the pace of economic growth and rate of capital investment have increased; by the inefficiency of the large integrated steel makers and recently by improvements in casting and rolling technology which have enabled them to produce high-quality sheet steel. They now account for more than 40 per cent of the annual tonnage of output in the US.

Given the global availability of technology in the metals industry, it is at first sight surprising that this small-scale, flexible technology has made so little headway in the EU. The main electric furnace-based producers are in Italy; Thyssen experimented with a plant based on the direct reduction of

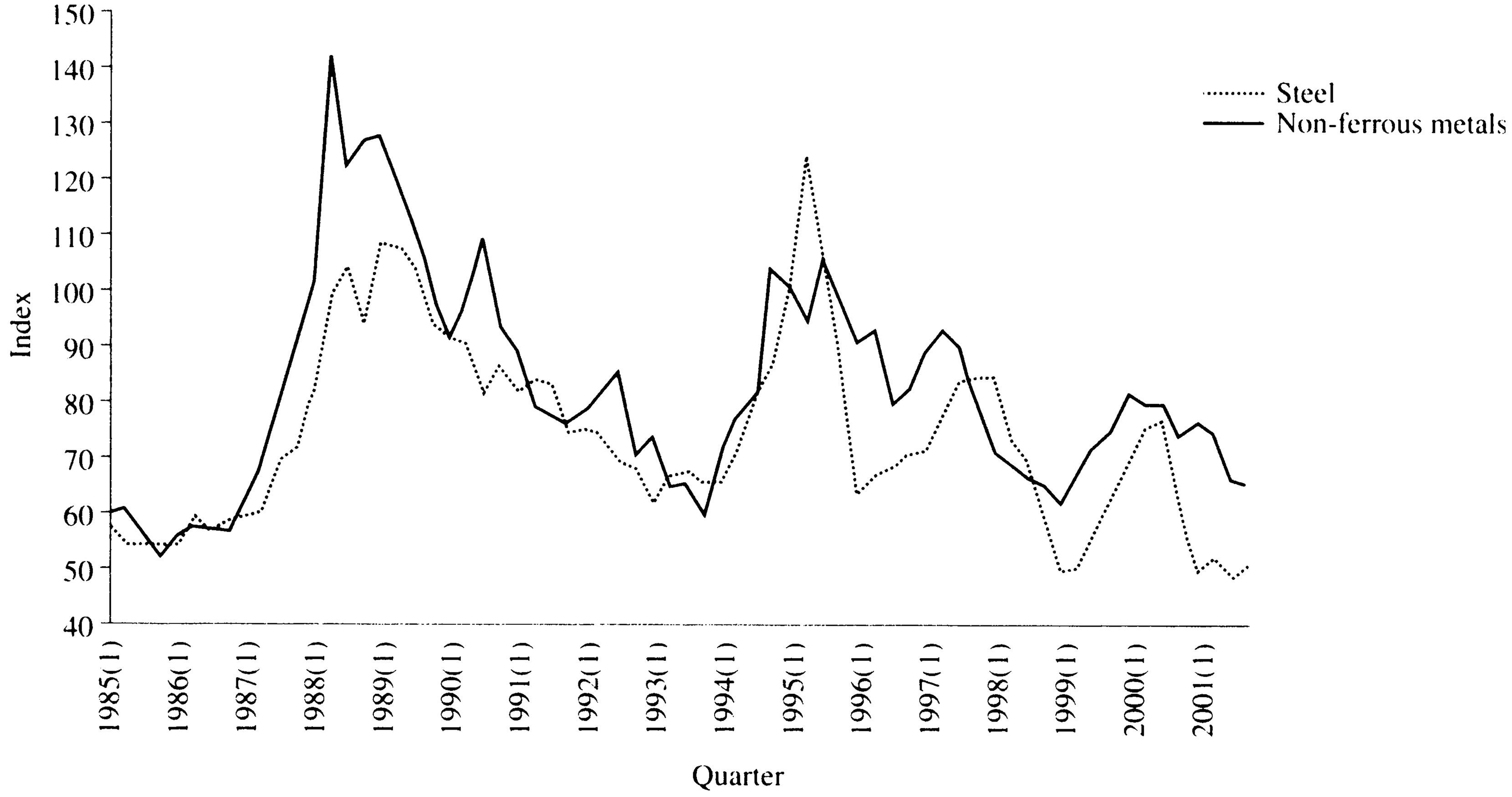
powdered ore in Hamburg before selling it on to Ispat: and most of the mini-mills built in the UK have subsequently been closed. Two reasons given for the relative absence of mini-mill production in the EU are high electricity prices relative to the costs of the traditional route of metal refining; and the greater cost competitiveness of European integrated mills. But at least as important must be the sunk investments of the large integrated companies, their largely depreciated capital stock, and their entrenched positions in the market. There has been no significant investment in new primary iron and steel manufacturing capacity in the EU since the capacity expansion programmes of the 1970s. Critical factors spurring the next stage of adjustment in the steel industry will be the need eventually to replace obsolete equipment; and reduction of tariff and quota protection on imports from outside.

Elsewhere in the metals sector, the main technological development has been in mining. Improved ore extraction techniques now allow formerly marginal fields to be worked profitably. Energy utilisation has been improved in aluminium refining. For other metals, incremental increases in productivity are the chief means by which efficiency is being increased.

PRICING AND MARKET CONDUCT

Price is the main dimension of competition in the metals market. Steel pricing resembles the manufactured goods market, in which producers state the prices at which they are willing to supply and may enter into long-term contracts with customers. In contrast, non-ferrous metals' pricing takes place in a commodity market, with prices moving continually through each trading day. Commodity-type pricing is tending to become more important for the market overall.

Figure 8.1 plots indexes of quarterly movements in the prices of the main metals from 1985 to 2001. Overall, prices are driven by: the rate of economic activity and, through that, by the demand for consumer and industrial goods; movements in the general level of prices (inflation); the amount of surplus capacity; and competitive conditions in the market, in particular the influx of imports. The trend of prices has been generally downward, reflecting a competitive market in which efficiency gains are passed on to customers in the form of lower prices.



Source: Steel: Metal Bulletin, ECSC mills, hot rolled coil, US$/tonne, indexed; non-ferrous metals: MG base metal cash price index, rebased.

Figure 8.1 Indexes of quarterly steel and non-ferrous metals prices, 1985Q1–2001Q4 (1995Q1 = 100)

Steel Prices

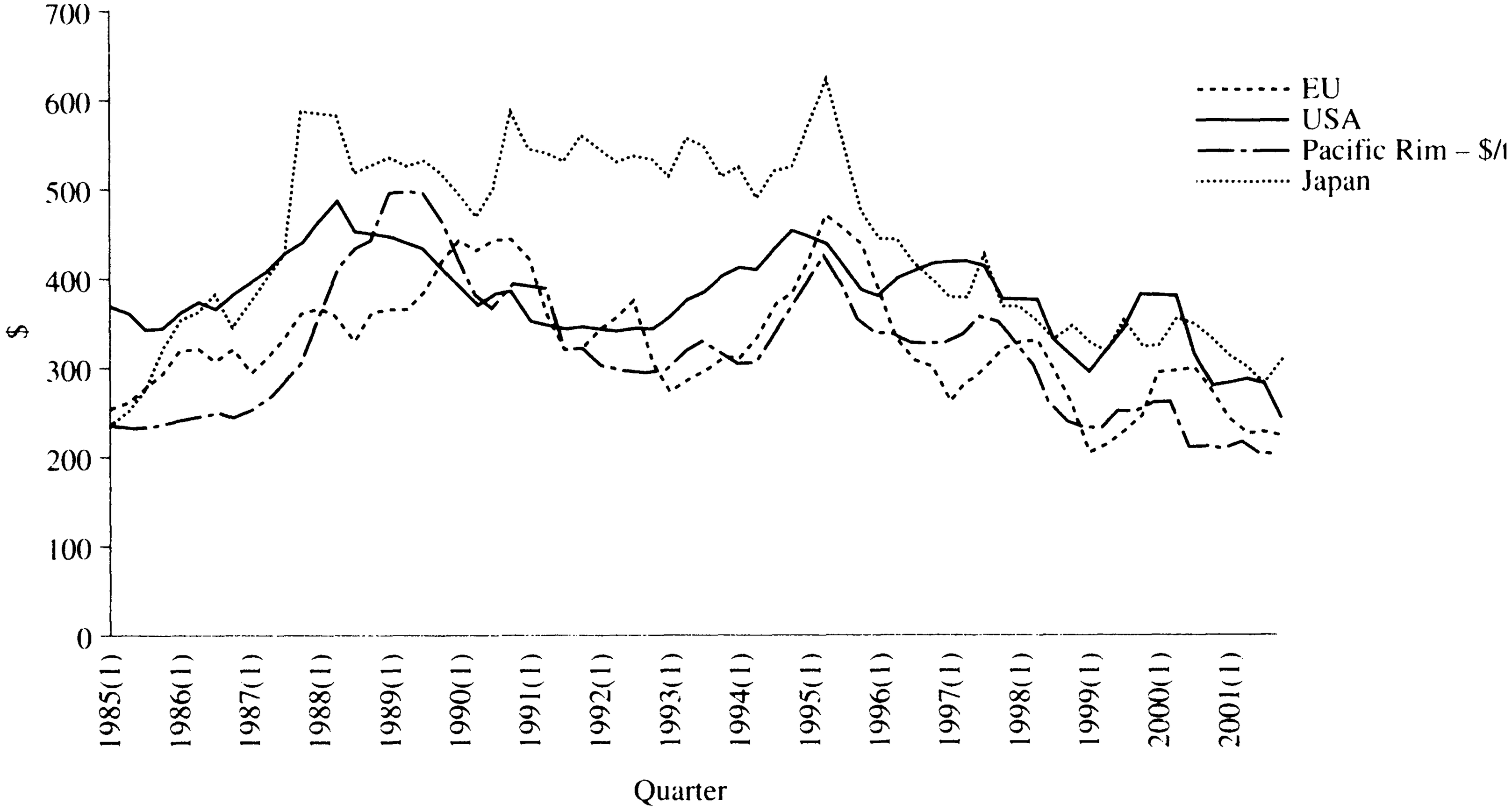
Germany sets the benchmark for steel prices in the EU, deriving from being the largest market in the EU and from its importance as a quality producer. The introduction of the Euro means that the scope for other Member States to maintain competitiveness through exchange rate depreciation has now been curtailed. As Figure 8.2 shows, EU prices move in line with world prices but typically stand at a discount to prices in the US and Japan and at a premium to world prices. The strength of US prices reflects the size and growth rate of the domestic market; the strength of the $; the relatively high cost of production; and the beneficial effect of quantitative limits on imports. Product quality and import controls contribute likewise to the premium against world prices in the EU market.

About two-thirds of the value of sales of the leading EU producers of flat-rolled products are under annual fixed-price contracts agreed with automotive and other large-scale purchasers. Contracts typically extend for three months or more and are subject to fierce negotiation. To control costs and maintain their own competitiveness, the major steel-users are reducing the number of preferred suppliers with whom they will deal and are imposing on them cost and quality conditions that are increasing in stringency. In turn, these pressures are driving steelmakers to rationalise their operations through cross-border mergers and by concentrating production on their best plants located close to their principal customers.

Long products typically are sold through a variety of outlets that act as wholesalers, and may carry out further processing; they are generally independent of the steelmaker. This part of the market has commodity characteristics: prices are quoted spot and move with the changing balance between demand and supply. Steel stockholders are an important channel into the EU market for low-price imports, in particular from central and eastern Europe and Russia. Surplus steel supplies move swiftly around the global market and surges of imports into the EU can rapidly depress prices.

Non-ferrous Metals Prices

Global prices for non-ferrous metals are set through the London Metal Exchange (LME). Metal is bought and sold in its semi-finished state, as ingots or slabs. Quality standards are clearly specified. The amounts of metal traded on the exchange are a very small proportion of total world sales but they set the benchmark for all contracts. Deals are concluded either on the basis of 'spot' prices for immediate delivery, or on 'futures', prices for delivery in three months' time. For any given type and quality of



Source: Industry data.

Figure 8.2 Quarterly movements of steel prices in the EU, US, Pacific Rim and Japan, 1985Q1-2001Q4, current US$

metal, the future price will normally be above the spot price, reflecting the seller's cost of holding the metal until the time for delivery.[7]

Prices are determined by two main forces: the market fundamentals of the supply–demand balance, and speculation. In the short run, the fundamentals are: the rate of off-take by end-users and merchants, which in turn is a function of the rate of economic activity; the current rate of output from refineries; the amount of available capacity; and movements into or out of stock. Producers, merchants and fabricators hold stock. In addition, the LME itself operates a worldwide network of warehouses, the chief purpose of which is to smooth price adjustments through the strategic release or purchase of metal. However, price levels may be disturbed if China or Russia, major metal producing and consuming regions that at present are on the periphery of the world trading system, choose to release metal onto the market from their strategic stockpiles, usually for foreign exchange purposes.

The fundamentals in the longer term are influenced by the world rate of economic growth on the demand side, and by exploitation of mining deposits and investment in new refining capacity on the supply side. The long-term elasticity of supply is low – opening new mines is a lengthy, expensive and risky process, and smelters are reluctant to build additional capacity until demand is evident. As a result, metal surpluses or shortages can persist for considerable periods of time, with consequences for prices and profits.

In addition to merchants, refiners and metal fabricators, the LME also attracts speculative trading in the spot and futures markets by financial houses investing hedge funds. A principal aim of these funds is to spread investors' risk by purchasing a portfolio of assets, the value of the components of which are expected to move in counterpoint. Hedge funds tend to move into metals and out of financial securities such as shares and bonds towards the middle of the upswing of the economic cycle, when interest rates are low, capital gains from securities are thought to be exhausted, and metals prices are expected to boom. They tend to move out, conversely, at the top of the cycle or in the early stages of the downswing. Although the funds' strategic aim is to diversify investors' risk, it is clear that their effect may be to destabilise rather than smooth price movements in the metals market.

Until recently, the LME has restricted trading to face-to-face 'open outcry' floor dealing. It has now introduced out-of-hours electronic trading. Internet trading of steel is also beginning to develop. The outcome is likely to be convergence on spot and futures trading for both ferrous and non-ferrous metals.

Conduct

The limited scope for sellers to differentiate their product in the market means that they are principally price-takers. Producers are typically large in relation to the markets they serve, capacity does not adjust smoothly or swiftly to variations in demand, and supply can be affected by changes in stocks and by import surges. Price fluctuations are severe and persistent over-supply damages profits. In these circumstances, firms will be highly interdependent in terms of their sales and marketing strategies. In theory, there is a risk that this may encourage tacit or explicit understandings between suppliers in respect of pricing and supply.

Strengthening the buyer–supplier relationship is important for large metals producers which serve major customers. Here, firms work closely with their customers to maintain and improve quality standards and to cooperate in the development of new products and processes. However, metal manufacturing technology is not proprietary to the suppliers, is globally accessible, and does not confer a competitive advantage on individual producers.

PERFORMANCE

In this section, the performance of the metals industry is assessed in both positive and normative terms. The positive assessment reviews the key indicators of output, productivity, trade and profitability; the normative assessment considers how closely the industry meets the criteria for economic efficiency.

Output

Over the period since 1988, the sector's output has declined in both absolute and relative terms. For a diverse set of products such as those in the metals sector, output is measured at constant prices – that is, by the monetary value of output (price *times* quantity), deflated by an appropriate index of inflation. Although the tonnage volume of output of both ferrous and non-ferrous metals increased as the EU and world economies expanded during the 1990s, growth was more than offset by the fall in commodity prices, so that measured output declined. The effect was most marked in the steel industry, less so in non-ferrous metals where prices, although low, showed more stability.

This fall in output, when coupled with the growth overall of manufacturing after the recession at the start of the decade, meant that the metals

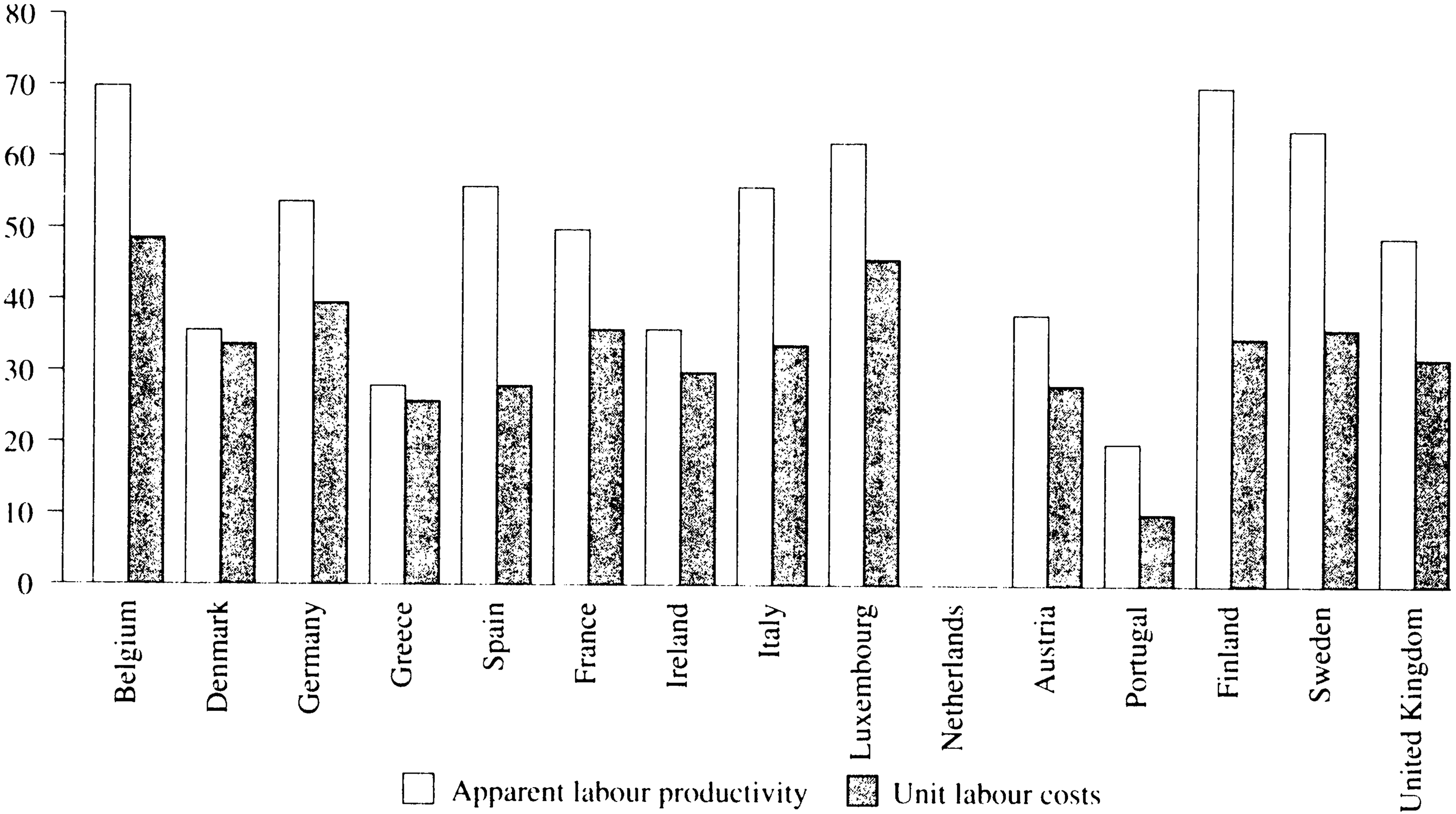
sector share of industrial production also declined. The overall pattern of absolute and relative decline was generally reflected at individual country level in the EU; Germany, in which metals maintained their share of manufacturing output, was the exception. In comparison, the metals sector also declined in importance over the same period in Japan, but not in the US, where it held its share of manufacturing output.

Productivity

Labour productivity (output per person employed) is a convenient but partial indicator of operating efficiency: convenient because output and employment data are usually readily available; partial because it neglects the contribution to output of capital. In the ten years from 1986, labour productivity in the EU metals sector increased on average at an annual rate of about 7 per cent, around twice the rate of increase in manufacturing as a whole. Given that value added per worker and, hence, productivity in this commodity-type sector have typically been low relative to the averages for manufacturing as a whole, the faster productivity rate of growth has served to close the gap somewhat. Against the background of declining output, the productivity improvement was achieved by a reduction in employment of one-third over the period.

Figure 8.3 shows considerable variation among the EU's Member States in levels of productivity and in labour costs per unit of output. The latter are influenced by productivity and by hourly employment costs (mainly wages). In 1997 the highest productivity rates were achieved by Finland, Sweden and (taken together) Belgium–Luxembourg. The first two are relatively small, specialist high value-added producers. For the major suppliers, Italy had the highest productivity, followed by Germany, France and the UK. The low-wage economies of Portugal and Greece had the lowest unit labour costs. Elsewhere, the advantage was with those countries that combined relatively high productivity with moderate employment costs. In the UK's case, the labour cost advantage arose because its low wages more than offset its low productivity relative to the other major producers. On an international basis, the EU's absolute value of output per head in the metals sector is below that in Japan and the US; productivity growth during the 1990s was faster than the pace in Japan but fell behind the rate in the US.

Overall, labour productivity in the metals sector has improved relative to manufacturing and in relation to Japan. However, when capital productivity is also taken into account, the gain in total factor productivity (output divided by labour and capital inputs combined) is probably more modest. This is because the financial rate of return on capital employed in the indus-



Source. Steel: Metal Bulletin, ECSC mills, hot rolled coil, US$/tonne, indexed; non-ferrous metals: MG base metal cash price index, rebased.

Figure 8.3 Apparent labour productivity and unit labour costs, by EU member state, 1997 ('000 ECU)

try has fallen, indicating an increase in the use of capital in relation to output, during a period in which employment has declined.

Trade

The pattern of decline demonstrated by output is reflected in the external trade accounts. At the end of the 1990s, the metals sector had a trade deficit equivalent to about 7 per cent of the value of annual output, a proportion that had increased over the preceding ten years, and in particular from 1995, when there was a surge of imports from the Russian Federation. Moreover, the sector's share of exports of all manufactures is falling.

For much of the period since 1990 non-ferrous metals have been the prime source of the trade deficit: despite increased export sales, imports have grown at a faster pace. Steel maintained a trade surplus, until 1998, but thereafter fell into heavy deficit.

Profitability

Eurostat measures the financial performance of industrial sectors in terms of the gross operating rate: that is, value-added *minus* personnel costs, all *divided* by turnover. This avoids the need to adjust for differences in accounting conventions, including the treatment of depreciation, but it means also that the burden of overhead and other operating costs in value added can lead industries to achieve positive gross operating rates but record financial losses.

From the end of the 1980s, the gross operating rate for the ferrous metals industry was well below the average for manufacturing until 1993, when rationalisation began to improve efficiency, moving the profit rate closer to the average of 8.6 per cent in 1997. The gross operating rate for non-ferrous metals has remained below the manufacturing average, running at 6.5 per cent in 1997, but the shortfall has not been as large as for iron and steel.

Economic Efficiency

The economic efficiency of an industrial sector may be appraised in three dimensions – technical, allocative and dynamic. Technical efficiency refers to the effectiveness (or productivity) with which a given set of resources is used in producing output. Allocative efficiency reflects the economic importance of price as a market signal for the appropriate allocation of scarce resources, and assesses the relationship between price and cost, in particular marginal cost. Dynamic efficiency considers the nature of the competitive process in a sector, and the speed and appropriateness of its

adjustment to changing conditions of demand and supply, in particular new technology and innovation.

The evidence on productivity reviewed above indicates that, since the end of the 1980s, the efficiency with which resources, particularly labour, are utilised has improved. Absolute productivity levels, however, are still below those in the US and Japan, and there are considerable variations across countries within the EU. This suggests that market rigidities and organisational slack within the system still prevent the metals sector from achieving its maximum technical efficiency.

Concerning the price–cost relationship within allocative efficiency, metals prices were generally weak during the 1990s as a consequence of persistent surplus capacity and strong competition from imports. In real (inflation-adjusted) terms, they declined steadily. The sector's poor profitability indicates that revenues were close to, and often below, full costs, suggesting that prices were moving towards marginal cost. In these terms, the price–cost relationship has not been inappropriate. Consumers have benefited from lower nominal and real prices, prices have reflected resource cost at the margin, and further capital investment in an overprovided sector has been deterred. However, the adjustment process, to bring supply capacity into balance with demand, is proving a very slow one. In various parts of the market, combinations of sunk costs, subsidies, the legacy of public ownership, and trade protection are impeding the elimination of inefficient and surplus capacity. Improvements in allocative efficiency are therefore being held back by failures on the part of both markets and public policy.

Market and policy failures impact in turn on the dynamic efficiency of the metals sector. Surplus capacity, low profitability and barriers to exit have discouraged innovation, investment in new technology and the entry of new enterprises. Concentration of output on large firms that have entrenched market positions means that the level of enterpreneurship has been low (Eurostat 2001, p. 254) and there has been reluctance in some parts of the sector to introduce small-scale technologies.

CONCLUSION

As measured by the real (inflation-adjusted) value of its output since the early 1990s, the EU metals sector has been declining both in absolute terms and relative to the global market. The sector's development is at the stage of late maturity. International competition is strong and is squeezing prices and profit margins. The market is treating products increasingly as undifferentiated commodities. Manufacture in the EU is highly concentrated by ownership and by Member State. Costs are sensitive to the scale of produc-

tion. Rationalisation is taking place slowly. But barriers to adjustment and to exit have maintained long-term surplus capacity and the adoption of new technology has been limited so far. Overall, against the background of slow demand growth and intensifying global competition, and in spite of improvements in operating efficiency, during the past decade the EU metals sector has tended to lose its competitive edge.

NOTES

1. This chapter was prepared during a period of research leave at the Brookings Institution, Washington DC. I am grateful to Bob Crandall, John Kwoka, Kevin Norrish, Tip Parker and Bob Thompson for helpful advice. The usual disclaimer applies.
2. Precious metals – gold, silver, and so on – are not covered, although they are included in the sector.
3. Using constant prices to measure output (a necessary requirement given the diverse output of this aggregated sector) means that the *tonnage* increase in output is understated. Strong international competition has held back increases in metals prices in relation to prices in general, thereby reducing the measured rate of output increase.
4. The US is the largest producer when output is measured in terms of value-added. This will reflect in part the higher degree of vertical integration and in part higher efficiency in the US industry than in the other two regions.
5. Some of the initial work on this is reported in Chilton (1960). The 0.6 rule indicates that if capacity is doubled, total costs will increase by around 52 per cent.; that is, *unit* costs fall by about a quarter.
6. See Cockerill (1973) for early work on this.
7. If metal supplies are currently scarce but are expected to increase, the spot price may rise above the future price. In this circumstance, the market is said to be in a state of 'backwardation'.

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